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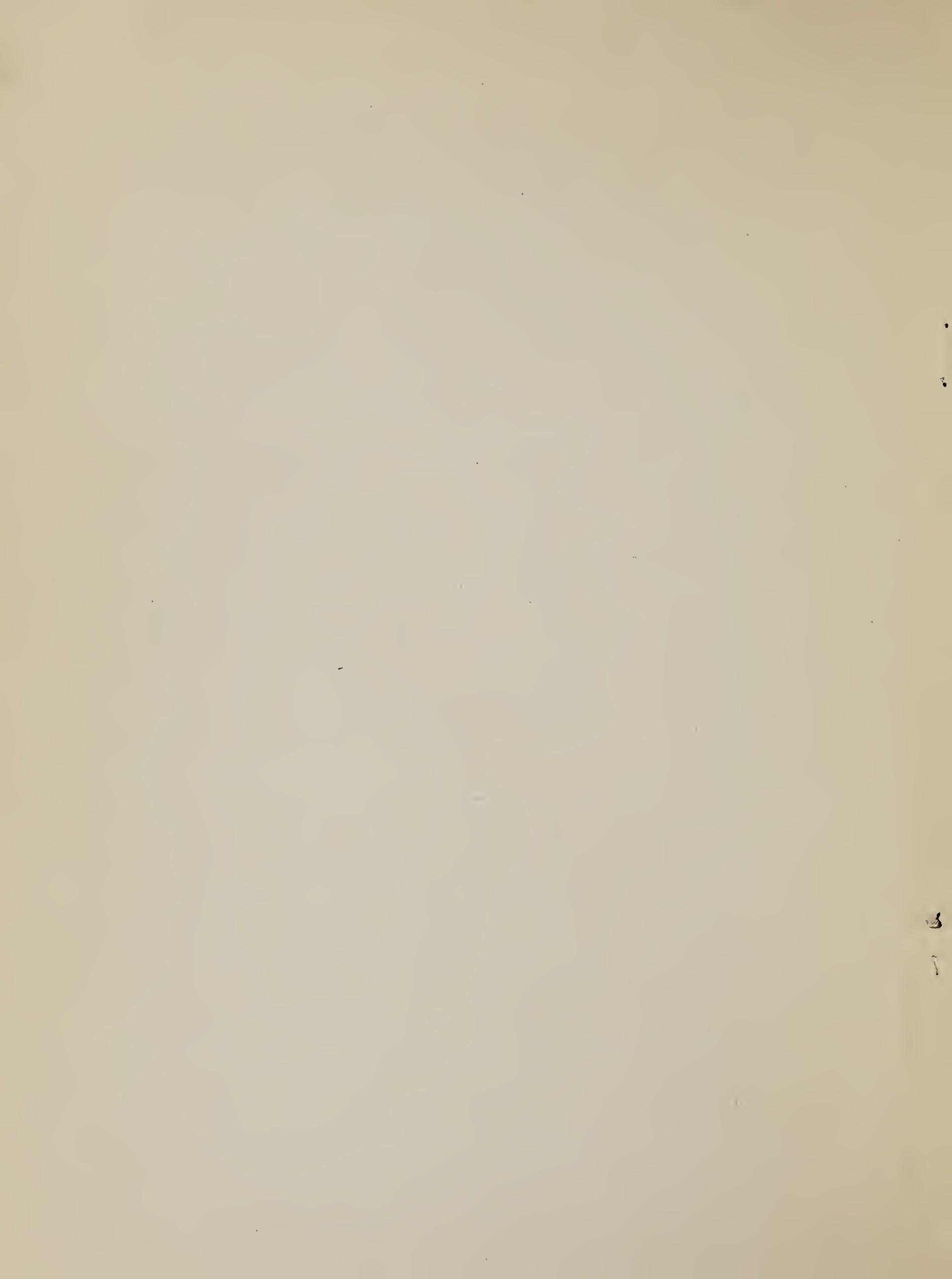
U. S. Department of Agriculture, Forest Service
FOREST PRODUCTS LABORATORY

In cooperation with the University of Wisconsin
MADISON, WISCONSIN

**EFFECT OF EXTRACTIVE SUBSTANCES IN
CERTAIN WOODS ON THE DURABILITY
OF PAINT COATINGS**

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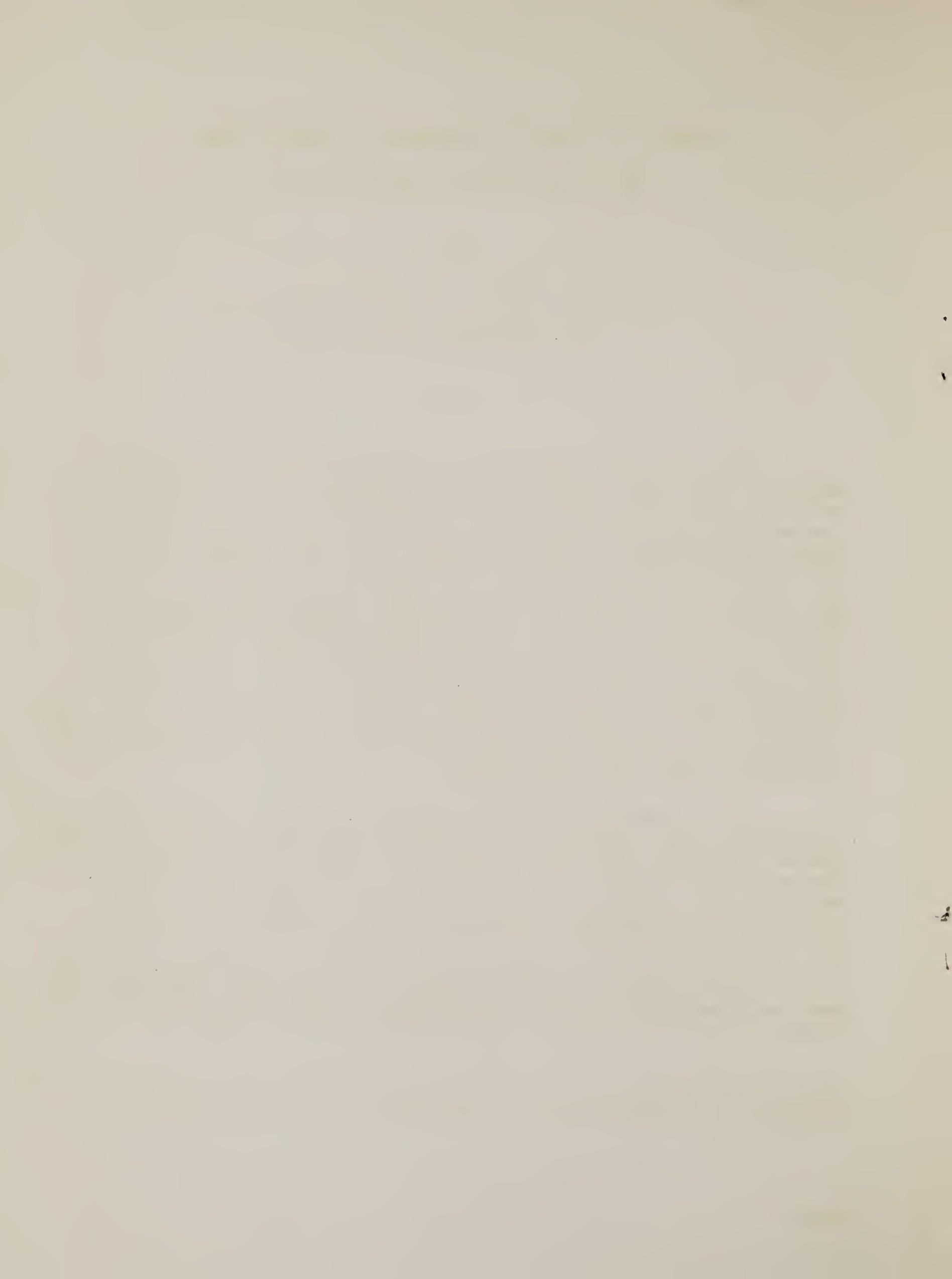
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For many years differences in the durability of house paints on different woods were commonly attributed chiefly to unfavorable effects of extractive substances, often indiscriminately called "resins," present in some woods. Many manufacturers of paint still write directions for application in which that idea is clearly reflected. Careful studies at the Forest Products Laboratory of the painting characteristics of woods (1), however, proved that physical structure is the dominant property of wood affecting the durability of house paint and that the importance of extractive substances has been greatly exaggerated (2). Certain minor trends attributable to an effect of extractive substances were observed but they were not always unfavorable. In redwood and southern cypress extractives seemed to prolong the life of paint coatings; in the white pines and yellow pines extractives seemed to shorten the life of coatings of a mixed-pigment paint containing zinc oxide but to exert little if any effect on the life of pure white lead paint.

The extractive substances in cypress, redwood, and the pines differ in nature far too seriously to be lumped together under any one designation such as "resins." Only those extractives of wood that are reasonably closely related to the resin of southern yellow pine ought to be called resins. Such extractives consist of a solid rosin and a volatile oil, usually turpentine. The principal extractive substances characteristic of the white pines and the yellow pines are of this type. The resin of ponderosa pine, which was used in the experiments described in this report, contains a rosin that is chiefly abietic acid (7) and a turpentine. Softwoods other than the pines contain resins but in smaller amounts and usually in localized deposits rather than diffused generally throughout the wood.

¹Maintained at Madison, Wis., in cooperation with the University of Wisconsin.



The characteristic extractive of southern cypress is oily in nature. It contains cypral, which is probably an aldehyde, and the sesquiterpene cypressene (5). Chemically and physically the oily substance in cypress differs markedly from the resins of the pines. Cypress may properly be called an oily wood but it should not be classed with the pines as a resinous wood. The characteristic extractives of redwood are soluble in water and consist of a complex mixture of leuco bases of certain dyes (dihydropyrene derivatives) (10), tannins, and the cycloses pinite (8) and sequoyite (9). Redwood should be considered a relatively nonresinous softwood.

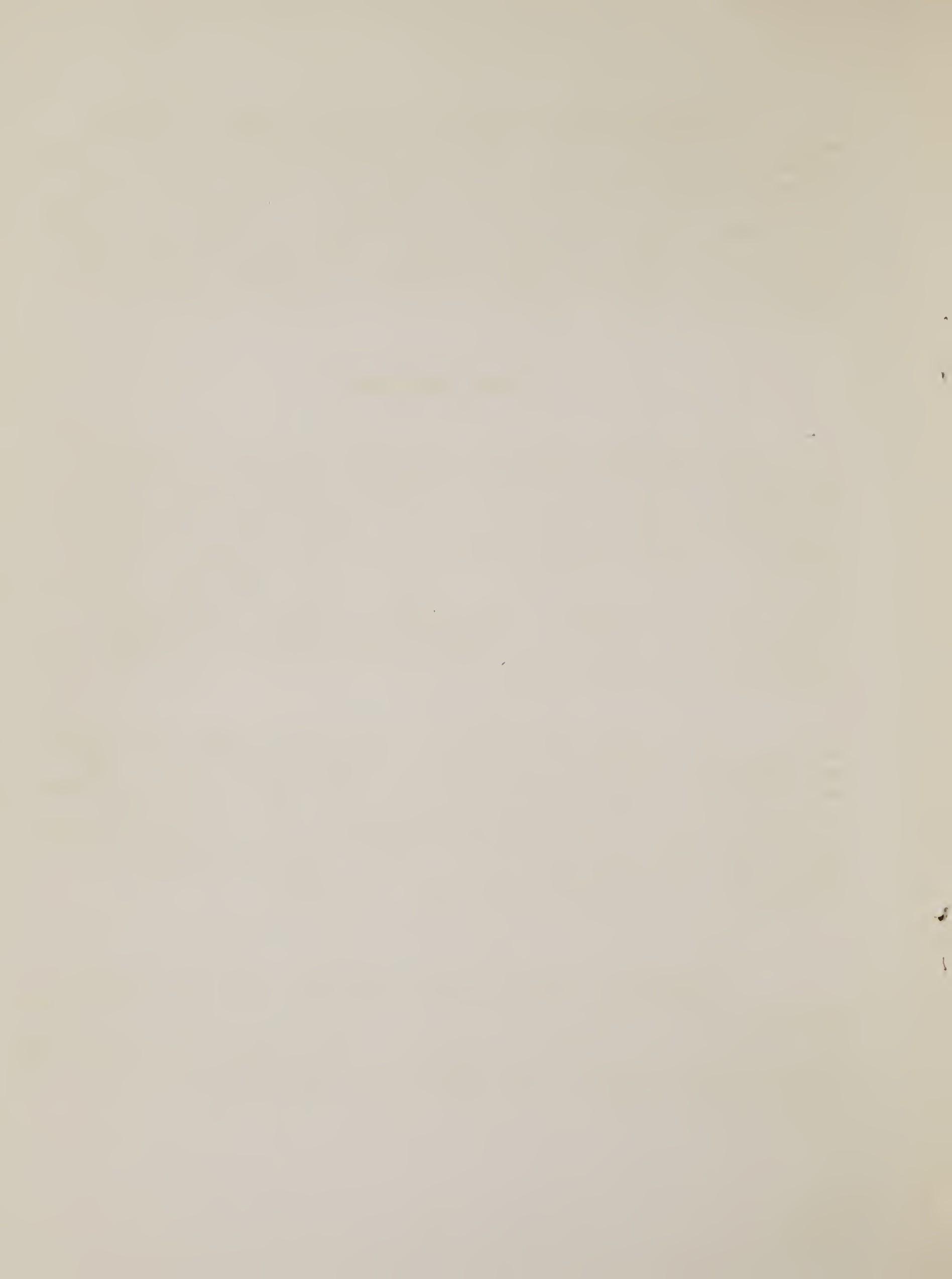
Testing Procedure

The following paragraphs present the results of tests conducted by the Forest Products Laboratory to determine the effect of extractive substances in certain woods on the durability of paint coatings. The general plan of these tests was to transfer the characteristic extractive substances of ponderosa pine, redwood, and southern cypress to parts of boards of a softwood lacking in characteristic extractives of its own, and then to test the durability of coatings of paint applied to both the treated and untreated parts of the boards. The wood chosen for the test panels was eastern hemlock. Unfortunately the eastern hemlock lumber available for the experiments was not of good quality and the average durability of the coatings was impaired by development of loose grain and checking in many of the boards.

Each test panel was 18 by 72 inches (0.45 by 1.8 meters) in size, made up of four boards of nominal 1/2 by 6 inch bevel siding. Each panel was marked off into three test areas each 18 by 24 inches (0.45 by 0.61 meters) of which the center area was the control area of untreated hemlock for comparison and the left- and right-hand areas were treated with extracts from other woods. After such treatment the entire panel was then painted with three coats of one of the paints and was exposed on a test fence in the vertical position facing south to observe the relative durability of the coating over the three test areas.

The extractive substances were prepared as follows:

1.--Redwood extract.--Redwood sawdust was extracted with cold water and the resulting solution concentrated by heating over a water bath. The concentrated solution was brushed on the desired test areas of hemlock panels and the water allowed to evaporate. The concentration of the extract and the weight applied were determined so that the amount transferred to the hemlock after the solvent evaporated could be calculated.



2.--Cypress extract.--Southern cypress sawdust was extracted with 95 percent ethyl alcohol and the extract concentrated over a water bath until on cooling incipient crystallization showed that the solution was saturated. The solution was then applied to chosen areas of hemlock panels as described for redwood extract.

3.--Ponderosa pine extract.--Ponderosa pine sawdust was extracted with 95 percent ethyl alcohol and the concentrated solution applied to chosen areas of hemlock panels as described for redwood extract.

In all cases the solution of extract was absorbed into the surface layers of the wood before evaporation of the solvent took place so that the extracts were deposited in the cavities of the wood rather than in the form of a coating over the wood. The surfaces were in no sense "primed" by the extracts and the subsequent behavior of the priming-coat paints was much like that on the untreated areas of the test panels.

Four paints were used as follows:

Paint L1.--A soft paste white lead paint containing 85 percent by weight basic carbonate white lead in raw linseed oil was thinned and applied in conventional three-coat work, being thinned for each coat as follows:

	<u>First coat</u>	<u>Second coat</u>	<u>Third coat</u>
Paste paint, lb. (kg.)	108 (0.49)	108 (0.49)	108 (0.49)
Linseed oil, gal. (l.)	3 (11.4)	0.5 (1.9)	2.5 (9.46)
Turpentine, gal. (l.)	2 (7.57)	1.5 (5.68)	0.125 (0.47)
Drier, gal. (l.)	0.125 (0.47)	0.125 (0.47)	0.125 (0.47)

Paint L2.--A soft paste paint containing 45.9 pounds (20.8 kg.) basic carbonate white lead, 18.3 pounds (8.3 kg.) English chalk, and 16.2 pounds (7.3 kg.) raw linseed oil was ground and substituted for 108 pounds of paste paint L1 in the above thinning formulas.

Paint LZ1.--A prepared paint was made containing 64 percent by weight pigment, composed of basic carbonate white lead 60 percent, zinc oxide 30 percent, asbestos 10 percent, and 36 percent liquid, composed of raw linseed oil 90 percent, drier and turpentine 10 percent. For the first coat 1 gallon of this paint was thinned with 1/4 gallon of turpentine and 1/8 gallon of linseed oil; for the second coat 1 gallon of the paint was thinned with 1/8 gallon of turpentine; for the third coat the paint was not thinned.

Paint LZ2.--A prepared paint was made containing 58.5 percent by weight pigment, composed of basic carbonate white lead 46.7 percent, zinc oxide 23.5 percent, English chalk 29.8 percent, and 41.5 percent of liquid of the same composition as that in paint LZ1. Paint LZ2 was thinned for application in the same proportions as paint LZ1.

The paints were applied indoors at Madison, Wis. One week elapsed between application of first- and second-coat paints and between second- and third-coat paints; during each of these intervals of drying the panels were taken out of doors for exposure to sunshine for 2 days. When the painting was completed the panels were shipped to the exposure stations and erected in the vertical position facing south in the fall of 1930. The stations at which exposures were made and the lay-out of the tests appear in table 1, together with the resulting durability of the coatings as judged by the writer's methods (2).

Results

On the whole the results accord reasonably well with expectations based upon the earlier tests of the painting characteristics of different woods.

The extract of ponderosa pine made pure white lead paint, L1, slightly more durable at Madison and Fresno and exerted no noticeable effect at the other stations while it impaired the durability of lead and zinc paint, LZ1, at Madison, Fargo, and Fresno, exerting no noticeable effect at Tucson and Washington. The evidence, therefore, is consistent with the view that the resin in the pines is responsible for the lower durability of paints containing zinc oxide on the pines as compared with the durability on softwoods of similar physical structure other than pines.

The extract of redwood improved the durability of white lead paint at Madison, Fargo, and Fresno and that of lead and zinc paint at Madison, Fargo, Tucson, and Washington, exerting no effects at the other stations. The fact that redwood holds paint longer than other softwoods of similar physical structure may therefore be attributed to a beneficial effect of some of the extractive substances present in redwood.

The extract of cypress improved the durability of white lead paint at Madison, Fargo, and Fresno and exerted no effect at the other stations; it impaired the durability of lead and zinc paint at Madison, Fargo, Tucson, and Fresno but improved the durability at Washington. The evidence is in line with expectations as far as white lead paint is concerned but is anomalous in the case of lead and zinc paint.

The antagonistic effect of pine resin on paints containing zinc oxide was attributed by the writer (3) to reaction between zinc oxide and the acids of rosin with resulting increase in the brittleness of the coating. This theory is essentially an extension of the widely accepted opinion (4) that the unique effects of zinc oxide in paints are due to chemical reaction with the fatty acids of linseed oil. Some technologists have long held that calcium carbonate, preferably in the form of English chalk, neutralizes undue acidity in paint coatings and thereby reduces the

Table 1.--Lay-out and results of tests

Panel No.	Position of test area on panel	Kind of extract applied to test area	Grams of dry extract applied to test area of panel exposed at --		Durability of coating in months at --	
			Paint applied	Age	Paint applied	Age
1	Left	Cypress	L1	28	37	46
	Center	None	L1	--	--	47
	Right	Redwood	L1	31	51	28
2	Left	Ponderosa pine	L1	29	28	46
	Center	None	L1	--	--	47
	Right	Ponderosa pine	L2	24	31	26
3	Left	Cypress	LZ1	37	36	36
	Center	None	LZ1	--	--	37
	Right	Redwood	LZ1	43	39	34
4	Left	Ponderosa pine	LZ1	31	25	26
	Center	None	LZ1	--	--	27
	Right	Ponderosa pine	LZ2	25	32	26

*The test fence at Washington was blown down in a windstorm at age 29 months. Coatings rated "Fair minus" in integrity at 29 months are arbitrarily given a durability rating of 35 months and those rated "Poor plus" at 29 months are rated 32 months.

danger of too much reaction with zinc oxide. For that reason paints L₂ and LZ₂ were applied over test areas treated with extract of ponderosa pine. The effect of the chalk on the behavior of the paints themselves, however, overshadowed any possible beneficial effect it may have had in neutralizing rosin acids. Both paints developed checking sooner and in a more conspicuous pattern than the corresponding paints without chalk; the durability of the white lead paint was thereby impaired only slightly but that of the lead and zinc paint was impaired seriously.

Effect of Extracts on Drying of Paint

In painting the test panels for the exposure tests the paints dried as rapidly on the areas treated with the extracts as they did on the untreated control areas. On air-dry redwood, cypress, and ponderosa pine lumber paints likewise dry as rapidly as they do on hemlock but in the presence of much moisture drying is retarded much more seriously on cypress and redwood than on hemlock or ponderosa pine (6). Accordingly some boards of hemlock with and without treatment with extracts of redwood, cypress, and ponderosa pine were placed in a room kept at 90 percent relative humidity and 80° F. (27° C.) until the wood had come to approximate equilibrium with those conditions. When the boards were painted while still in this room the following results were obtained: On untreated hemlock and on hemlock treated with the extract of ponderosa pine the paints required only a few hours longer to dry than they did when applied to wood at approximately 11 percent moisture content and in a reasonably dry atmosphere. On hemlock treated with the extracts from redwood and cypress the priming-coat paints remained liquid for several days and the drying of subsequent coats was retarded very materially. Transfer of the extracts of redwood and cypress to hemlock therefore made the hemlock act just like redwood and cypress lumber with respect to the drying of paint.

Conclusions

1. When the extractive substances of redwood, southern cypress, and ponderosa pine respectively are transferred to the surfaces of boards of eastern hemlock, a wood lacking in characteristic extractive substances of its own, the hemlock acquires some of the painting characteristics of the wood from which the extract is taken.

2. The experiments substantially confirm an earlier deduction that extractive substances in certain woods affect the durability of paint coatings, sometimes favorably, sometimes unfavorably, although the effect of such extractive substances is much less important in paint life than the physical structure of the wood.

List of References

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- (5) Odell, A. F., J. Am. Chem. Soc. 33: 755 (1911).
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- (8) Sherrard, E. C., and Kurth, E. F., Ind. Eng. Chem. 20: 722 (1928).
- (9) _____, J. Am. Chem. Soc. 51: 3139 (1929).
- (10) _____, J. Am. Chem. Soc. 55: 1728 (1933).



Figure 1.—Beneficial effect of extract from ponderosa pine on durability of white lead paint.
Area at left treated with extract, area at right untreated. Photographed after
exposure for 43 months at Madison, Wis.

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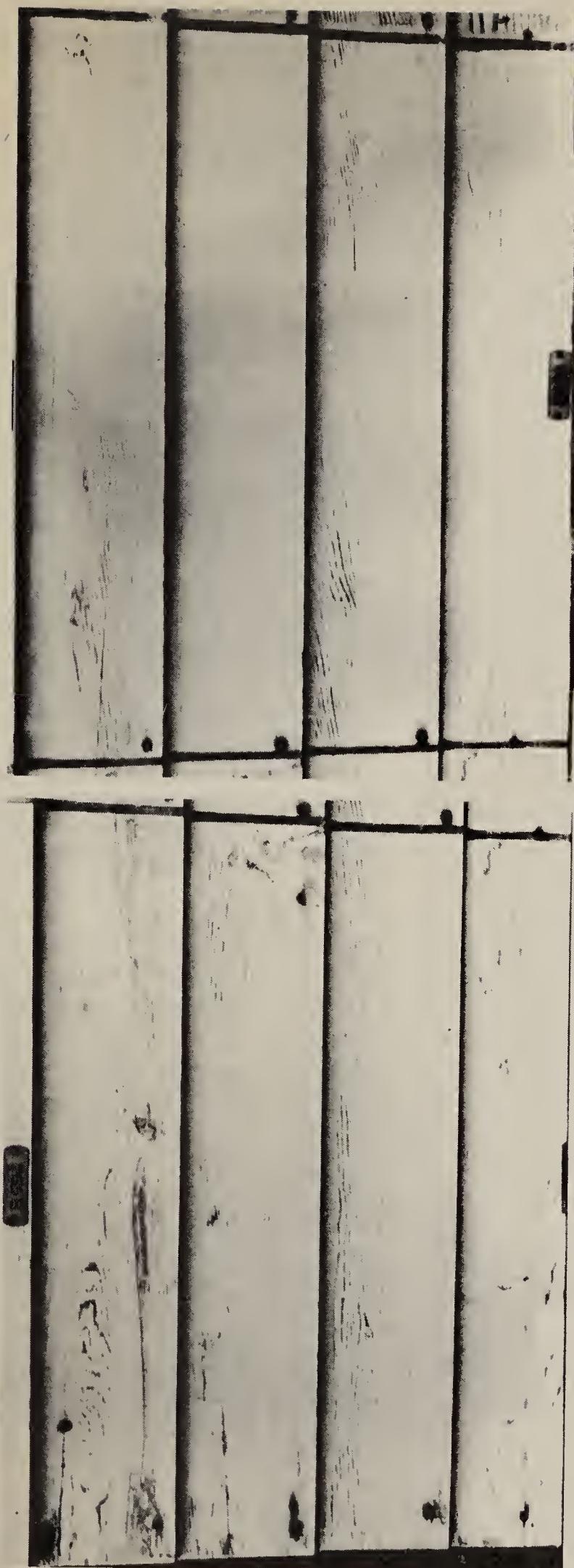


Figure 2.--Detimental effect of extract from ponderosa pine on durability of lead and zinc paint. Area at left treated with extract, area at right untreated. Photographed after exposure for 4½ months at Madison, Wis.

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